A SECOND AUSTRALIAN SPECIES OF THE GONDWANAN STAG BEETLE GENUS *SPHAENOGNATHUS* BUQUET (COLEOPTERA: LUCANIDAE)

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Sphaenognathus (Australognathus) munchowae sp. nov. is described from two high tablelands of central Queensland and is regarded as a sister species of *S. (A.) queenslandicus* Moore, known only from the rainforest of the Carbine Tableland in the north of the state. Information on the biology and habitat, including immature stages, of the new species is presented. ❑ *Insecta, Coleoptera, Lucanidae, Australia, stag beetle, biology.*

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The discovery, in 1973, of a single male of an Australian species of *Sphaenognathus* Buquet, living in high-altitude rainforest of northern Queensland, was an event of considerable zoogeographical significance, for hitherto, this genus of stag beetles was known only from the Neotropical region. Subsequently, when further males became available from the type locality (Mt Lewis on the Carbine Tableland), this species was described by one of us as *S. queenslandicus* (Moore, 1978) and was interpreted as being a Gondwanan relict.

DISCOVERY OF SECOND SPECIES

By strange coincidence, a dead female of an apparent second species of *Sphaenognathus* was also discovered in 1973, by a young bush-walker, Elizabeth Munchow, in open *Eucalyptus* woodland on the isolated Blackdown Tableland, inland from Rockhampton and some 950 km SSE of Mt Lewis. This enigmatic specimen was given to local collector Ernest Adams, who, following publication of *S. queenslandicus* in 1978, recognised its similarity to that species and donated it to the ANIC, Canberra. However, because the female of *S. queenslandicus* was then unknown, little informative comparison of the two populations was feasible.

Despite intensive search at Blackdown by several entomologists, no male from this southern population became available for study for many years. However, a second dead female was found, out of season, in May 1993, by a Queensland Museum party on the remote, high Consuelo Tableland in the Mt Moffat Section of Carnarvon National Park. In an attempt to get further specimens, three long-term, flight intercept traps, with 1.5m^2 panels, were installed at that locality by the Queensland Museum in September 1995, with the intention of operating them right through the summer season, during which emergence of adult beetles could be expected. The traps were cleared in November 1995 without success. At the final clearance, in late February 1996, one of the traps contained a pair of large adult *Sphaenognathus*, including the first available specimen of the critical male sex. Field search on the same occasion located a colony of larvae, of all stages, beneath a large rotten log, together with fragments of dead female adults. Fifty six living larvae were taken back to Brisbane, together with a large amount of the wood as food. Over the following 46 months, 6 males and 2 females, were reared from these larvae.

Following success with larval collection at Consuelo Tableland, GBM revisited Blackdown Tableland on 11-12 April 1996, and searched under logs. A single, 3rd instar larva, identical to those from Consuelo, was located but it died several months later without transforming.

From August 2001 to Feburary 2002, Queensland Parks and Wildlife Service staff surveyed fauna at 11 sites on the Consuelo Tableland. Small insect pitfall traps were operated continuously at all sites and flight intercept traps at 4 sites. Eight large dry pitfalls for vertebrates were operated at each site for a week in November and again in February. No *Sphaenognathus* were taken in the insect traps, but 6 living females were taken in the vertebrate pitfalls at 3 of the 11 sites during the February trap period. The absence of males may be explained by the more terrestrial habits of the females favouring their capture.

Study of these collections confirms that the Blackdown and Consuelo populations are identical and constitute a second Australian species of the genus, which is described below.

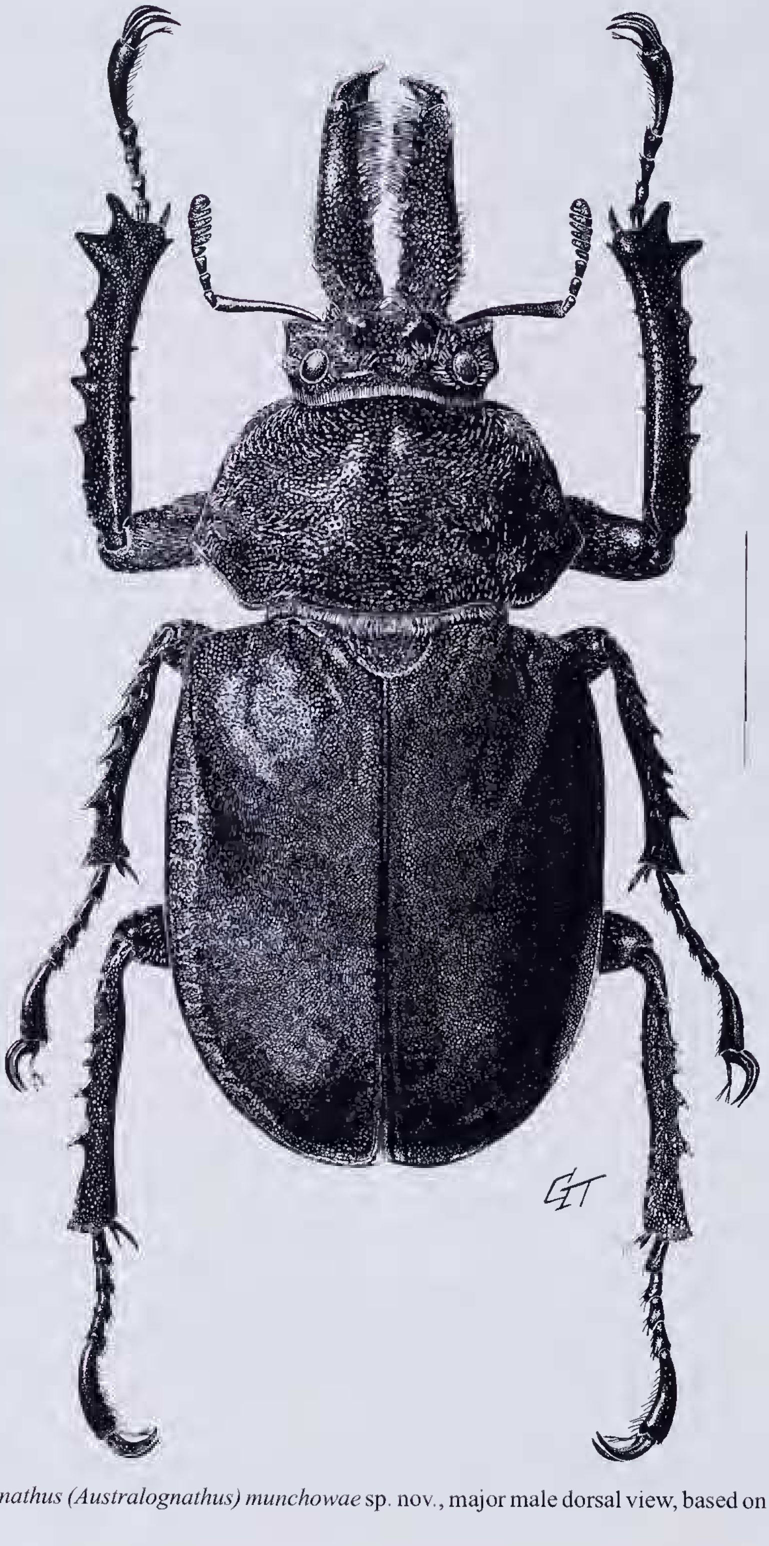

FIG. 1. *Sphaenognathus (Australognathus) munchowae* sp. nov., major male dorsal view, based on holotype. Scale line 10mm.

GENERIC PLACEMENT

Chalumeau & Brochier (1993) erected a new genus, *Australognathus*, for *S. queenslandicus* and described the female of the species from material provided by us. This classification is maintained in their subsequent synopsis of the group (Chalumeau & Brochier, 1995). However, as the Australian species differ from those from South America in only minor ways, essentially restricted to the male sex, we prefer to treat *Australognathus* as a subgenus of *Sphaenognathus*.

Abbreviations for specimen depositories are: ANIC, Australian National Insect Collection, Canberra; MDPI, Department of Primary Industries, Mareeba; QM, Queensland Museum, Brisbane.

Sphaenognathus (Australognathus) munchowae sp. nov.
(Figs 1-6)

ETYMOLOGY. Named for its discoverer, Elizabeth Munchow.

MATERIAL. CENTRAL QUEENSLAND. HOLOTYPE ♂, QMT108919, Mahogany Forest, Mt Moffatt NP, 24°56'S 148°04'E, 1200m, 25.xi.1995-25.ii.1996, flight intercept trap, G.B. Monteith (QM). PARATYPES, 1♀, same data as holotype (QM); 1♀, same locality, 24-26.ii.1996, G.B. Monteith (reconstructed from parts of dead specimen, QM); 6♂, 2♀, coll. as larvae same locality and date, emerged as adults as follows: 1♂, em. Mareeba, 14.ix.1998 (MDPI), 2♂, 2♀, em. Brisbane, x.1998 (QM), 1♂, em. Brisbane, 27.xi.1996, deformed, not paratype (QM), 2♂, em. Julatten, i. & xii.1999 (ANIC); 1♀, same locality, 29.v.1993, R. Sheridan (coll. as dead specimen, QM); 3♀, same locality, pitfall trap, Site 9, 11-20.ii.2002, C. Eddie (QM); 2♀, 2.2km SSW Peawaddy Gorge Lookout, 24°56'S 148°04'E, pitfall trap, Site 35, 11-20.ii.2002, C. Eddie (QM); 1♀, Foley's Spring, Mt Moffatt NP, 24°57'S 148°08', pitfall trap, Site 32, 11-20.ii.2002, C. Eddie (QM); 1♀, Blackdown Tableland, ii.1973, E. Munchow (coll. as dead specimen, ANIC).

DESCRIPTION. *Male* (Figs 1, 2B, 3, 4A-B, 5A). Entirely dark, pitchy-black, without metallic tints. Upperside matt; underside with sparse greyish pubescence. Length (including mandibles), 34-48mm (HT, 48mm); max. width 15-19mm (HT, 19mm).

Head. Small, very transverse, rugosely punctate and thinly pilose, except on vertex and frontal bullae; canthi sinuate, their anterior angles sharp and prominent, their posterior angles obtuse but well marked; mandibles (Figs 1, 2B, 3) slender, porrect, somewhat longer than pronotum, the left (length, 6-11 mm; HT, 11mm) a little longer than the right, both strongly (in holotype, abruptly) downcurved in lateral view, with apices acute and inturned and with two prominent, closely approximate teeth internally, rather strongly

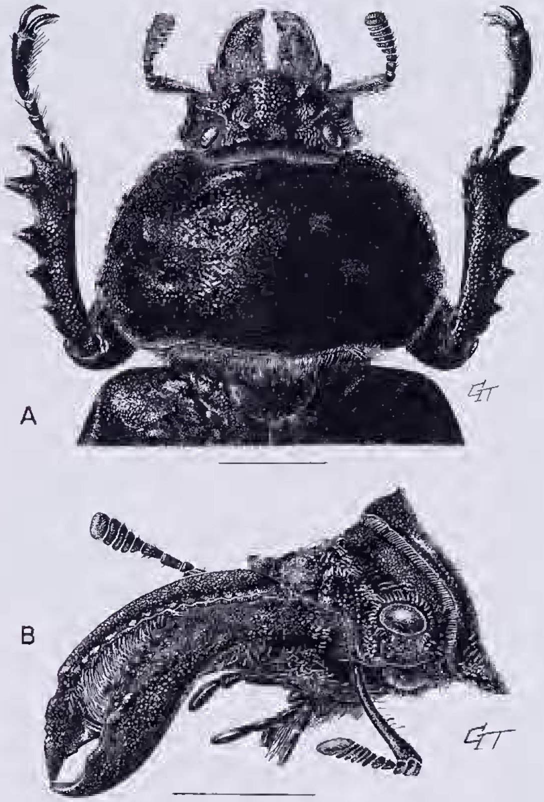

FIG. 2. *Sphaenognathus (Australognathus) munchowae* sp. nov., A, female foreparts; B, major male head and mandibles in oblique left lateral view. Scale lines 5mm.

pilose beneath the denticulate upper internal carina; mandibular dorsal carina obsolete except near apex; lower internal carina obsolete except near base, there terminating in a small, subconical, sometimes bifid, ventral tooth; mentum entire, trapezoidal; eyes subcircular dorsally and ventrally; antennal club clearly 6-segmented.

Pronotum. Gibbous, transverse (HT, 17 × 10mm), broadest at basal quarter, where margins subdentate; entire upper surface coarsely and irregularly punctate, sparsely pubescent, except on disc.

Elytra. Broad, rather convex near scutellum, matt and almost smooth, glabrous; humeri subangular, swollen; scutellum small, transverse, finely rugose; hindwings fully developed.

Legs. Slender; fore-tibiae slightly arcuate, strongly bidentate apically, outer and ventral margins irregularly denticulate; mid- and hind-tibiae almost straight, externally irregularly but acutely multidentate; tarsi long, shining; onychium setose beneath.

Aedeagus (Fig. 4A,B). Well sclerotised; penis with characteristic sclerotisation pattern; everted portion with long flagellum; parameres bare.

Female (Figs 2A, 5A). Similar in colour to male but upper surface darker and more shiny; body broader; *head* with mandibles short, outwardly regularly curved, inwardly sinuate or vaguely dentate; vertex subtuberculate; *pronotum* more transverse, with lateral angles less marked; *elytral* sculpture more rugose; *tibiae* shorter, broader, dentition stronger, especially sharp on mid- and hind-tibiae; fore tibiae without ventral dentition; spermatheca (Fig. 4C) well sclerotised, constricted in middle, at entry-point of accessory gland; styli short, ovoid and pilose as in most other species of the genus (Bartolozzi et al., 1992). Length (including mandibles), 35-44.6mm; max. width, 13-22.5mm.

Variation. Lengths of mandibles in minor males only some 55% of those of holotype, less down-curved in lateral view and with the upper internal carina less marked; anterior angles of canthi sometimes truncate; tibial teeth variable in numbers in both sexes, often showing lateral asymmetry.

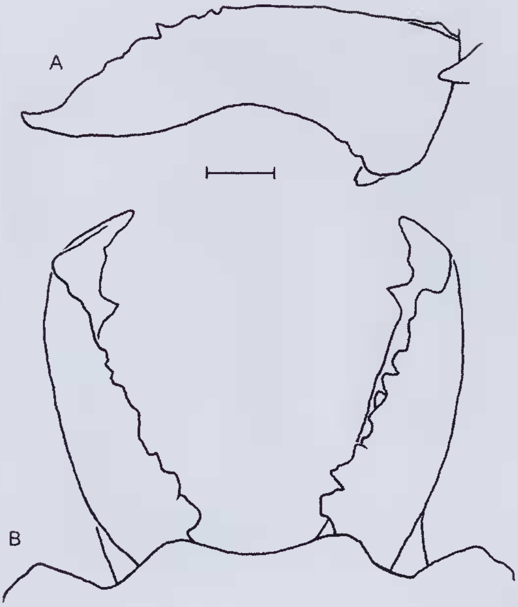

FIG. 3. *Sphaenognathus (Australognathus) munchowae* sp.nov., mandibles of minor male. A, lateral view; B, dorsal view. Scale line, 1mm.

REMARKS. Although evidently closely related to *S. (A.) queenslandicus*, the new species differs in its larger size, uniform dark colour, unicolorous tibiae with much stronger dentition in both sexes, its angular and more prominent canthi and its clearly 6-segmented antennal club (in *S. queenslandicus* antennomere 4 is slightly expanded). Major males of *S. munchowae* have longer and more slender mandibles than have yet been seen in any males of *S. queenslandicus*. In all males of the new species, the mandibles are much less expanded basally, and show different dentition. The penis in *S. munchowae* shows a distinct sclerotisation pattern and bears a longer flagellum.

HABITAT AND DISTRIBUTION. Geologically, much of inland central Queensland is sandstone, laid down under Mesozoic seas. The present uplifted surface has been considerably eroded leaving many isolated, residual plateaus representing fragments of the original flat terrain. The two localities where *Sphaenognathus munchowae* has been discovered, Blackdown and Consuelo Tablelands, are the largest and highest of these residual plateaus. Blackdown reaches 900 m altitude and lies 180 km from the coast at 23°45'S. Consuelo is 150km SSW of Blackdown, reaches 1200m, and lies 370km inland at 25°00'S.

Both areas are quite remote and have been biologically explored comparatively recently. The environment of both is cool, wet and heavily forested in comparison with the hot, dry, sparsely vegetated surrounding lowlands (Henderson, 1976). Botanically and entomologically, these two tablelands have a strong refugial character, supporting species which differ from the surrounding lowlands, including many endemics and many highly disjunct populations, particularly of species known otherwise from further south in Australia (Atkins, 1974; Henderson, 1976; Monteith & Yeates, 1988; Rentz, 1986). These features support our view that the two populations of *S. munchowae* are remnants of a more widespread distribution dating back to Gondwanan times when Australia was in contact with southern land masses and before erosion isolated the current plateaus.

At each locality, records of the beetle are from the highest rainfall sectors of the plateau, where the eucalypt forest habitat is tallest. At Blackdown this lies at the northeast corner of the tableland. At Consuelo this lies at the SW corner where a basalt soil overlay to the sandstone supports a dense stand of *Eucalyptus nitens*, known locally as the 'Mahogany Forest'. This suggests that the range of the species is much smaller than that of the entire plateaus and thus may be vulnerable to collecting. However both areas lie entirely within protected reserves.

The eucalypt forest habitat of the new species contrasts strongly with the high altitude tropical

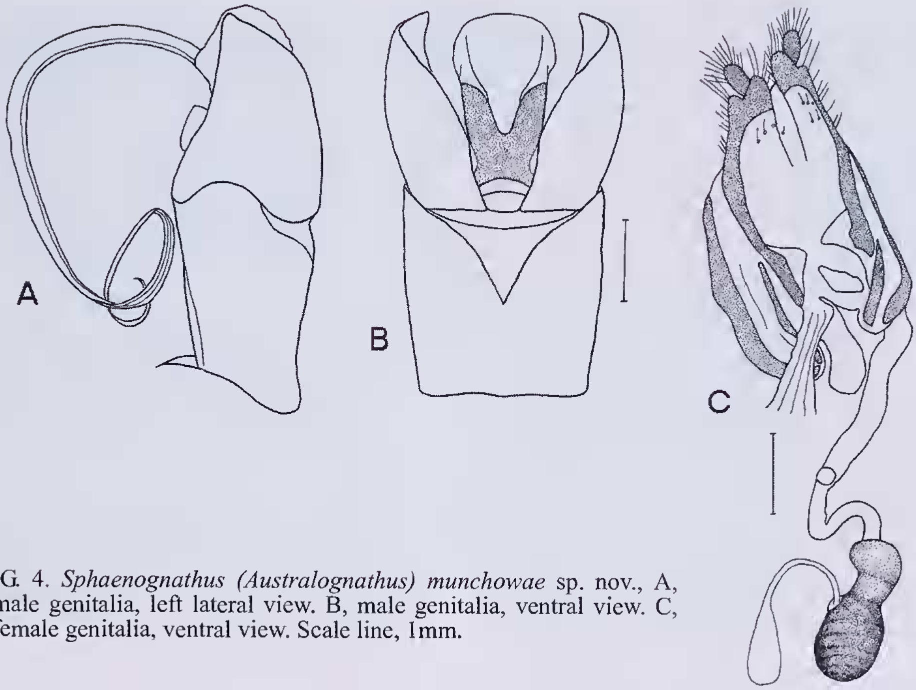

FIG. 4. *Sphaenognathus (Australognathus) munchowae* sp. nov., A, male genitalia, left lateral view. B, male genitalia, ventral view. C, female genitalia, ventral view. Scale line, 1mm.

rainforest habitat of *S. queenslandicus* in north Queensland. A few additional specimens of this species have been taken (Chalumeau & Brochier, 1993) since its original description. All are from within a radius of about 20km on the Carbine Tableland, a mountain massif known for endemic and Gondwanan insects (Monteith, 1980; Yeates et al., 2002)

LIFE HISTORY NOTES. Details of life history and morphology of immature stages are given for 6 species of Peruvian *Sphaenognathus* by Onore (1994). These species are atypical among Lucanidae in that larvae live freely in the soil, rather than in rotten wood. Several species are described as coating their abdominal segments 3-5 with soil. Although all life history stages of *S. munchowae* were collected, only preliminary comments on their morphology will be made in this paper.

Adult Seasonality. No living adults of *S. munchowae* have been directly hand collected, so information on activity periods derives from trap catches at Consuelo Tableland. Traps were operated continuously from spring to late summer in years 1995/96 and 2001/02. During the first series a male and female were taken between Nov 25 and Feb 24. Since both were in the same trap, and appeared quite fresh, it can be speculated that they were trapped in the latter part of the trap period and they may have been a courting pair. During the second trap series six females were taken, all between 11-20 February. These two trap catches would suggest late summer adult emergence. However all artificially reared larvae moulted to adults during spring-early summer (September-January). The explanation for this apparent anomaly is probably that, in the field, adults remain in their subterranean pupal chambers until summer rains, highly sporadic in the region, trigger emergence and mating.

Larval Habitat, Behaviour and Seasonality. Unlike the South American species (Onore, 1994) all larvae of *S. munchowae* have been taken feeding on wood of very old, rotten logs deeply embedded in the ground. At Consuelo, logs were of *Eucalyptus* trees; at Blackdown the single occurrence was under a small *Casuarina* log. Unlike most lucanid larvae which live within the wood, *S. munchowae* larvae live in a chamber beneath the log, lying on the soil and feeding on the underside of the log above them. Small larvae sometimes burrow partly into the wood but large larvae are invariably either partly embedded in the soil surface or free in the feeding chamber where they lie on a bed of their distinctive, hard, circular, flattened faecal pellets which are deeply notched on one side (Fig. 5B,D).

Larvae are very long-lived and large logs clearly support many generations of larvae over many years. All larval stages may be present

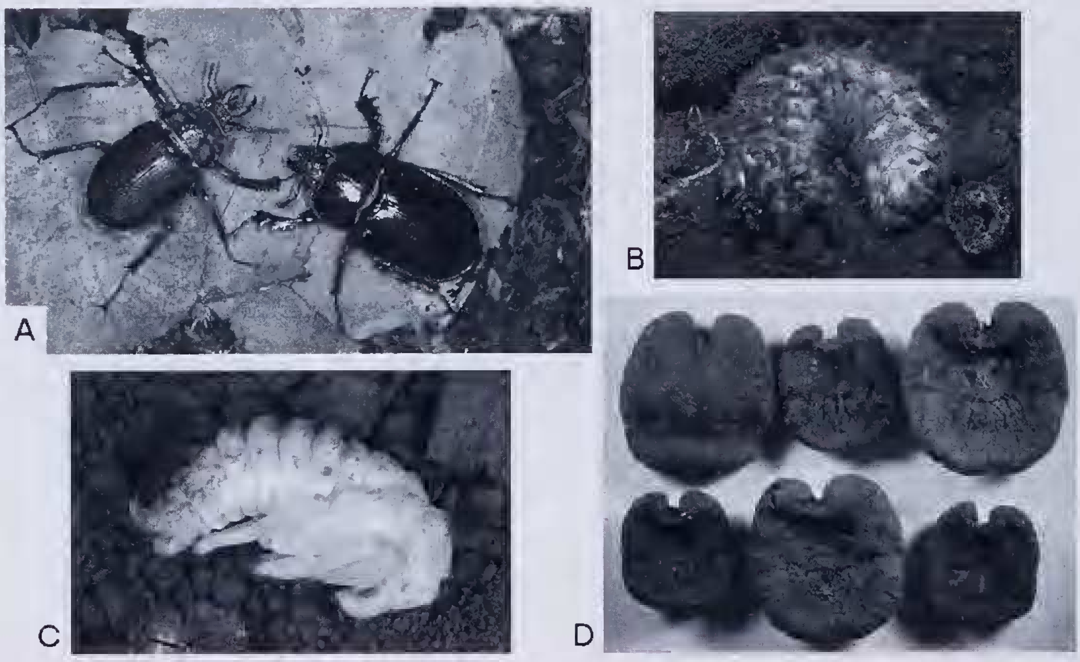

FIG. 5. *Sphaenognathus (Australognathus) munchowae* sp. nov., A, living minor male (left) and female, reared from Consuelo Tableland larvae (photo Gary Cranitch, QM); B, third instar larva from Consuelo Tableland (photo Steve Wilson); C, male pupa, lateral view (photo Paul Zborowski); D, faecal pellets of second (small) and third (large) instar larvae.

synchronously. From the large log investigated at Consuelo on February 25, 1996, 3 eggs, 6 first instars, 23 second instars and 27 third (final) instar larvae were collected. These live larvae were returned to Brisbane to attempt rearing of further adults. To provide a range of climates and breeding expertise, some were sent to colleagues in Mareeba, Julatten and Innisfail (tropical) and Mt Glorious (subtropical), with the bulk of them retained in Brisbane (subtropical). Larvae were kept in individual jars and fed readily on wood from the original log. Eight months later, one Brisbane larva formed a pupal cell in early October, pupated on October 10 and emerged as an adult male on November 27. No further metamorphosis occurred for another two years until September, 1998, when some larvae in Brisbane and Mareeba began to pupate leading to emergences in October of 4 females in Brisbane and 1 male in Mareeba. Two more males at Julatten emerged in January and December, 1999. Since the last Julatten larva was already final instar when first collected 46 months earlier it appears that larval life is very lengthy. All other larvae eventually succumbed, mostly to fungal attack. Preserved specimens of all instars are held at QM and final instars are in ANIC.

Eggs. White, oval, and measure 3.8 × 2.8mm. Of the three collected in February, 1996, one hatched within a week and the others, with larvae visible inside, were preserved.

Larvae. Easily separated from other Australian lucanid larvae by their coarsely hairy bodies (Fig. 5B) and the two prominent, oval, anal pads, both characters described by Onore (1994) for *Sphaenognathus*. First and second instars are clean and white but third instars have their whole body coated with a thin layer of soil, an accentuation of the situation described by Onore for South American species. Dimensions for larvae of *S. munchowae* are: first instar, max. length 15mm, head capsule width 2.6-2.7mm; second instar, length, 35mm, head capsule, 5.2-5.6mm; third instar, length 65mm, head capsule, 9.2-10.6mm.

Larval Stridulation. Larvae have the normal lucanid stridulatory mechanism of a toothed plectrum on the hind leg which moves against a stridulitrum ridge on the mid coxa. Onore (1994) notes that the sound produced by South American species is not audible to the ear, but can be felt through the hand. He speculates that it may be used to reinforce spacing between larvae in soil. The Australian larvae also stridulate vigorously when handled and are also inaudible to the ear but detectable in the hand. In May 1997, recordings of stridulating larvae were made, showing clear substrate-borne pulses of vibrations (Fig. 6), with legs on each side of the body operating alternately. Stridulation in captive larvae was only triggered by contact which indicates it may be a soil-borne proximity signal as suggested by Onore (1994).

Pupation. Captive larvae always burrowed to the bottom of the jar before forming a pupal cell. This suggests that in the field they pupate deeper within the soil beneath their feeding log. Pupae (Fig. 5C) lie on their back in the pupal chamber, supported above the substrate on two swellings on the pronotum and a series of five raised transverse ridges, each with inflected margins, which run across abdominal terga 1-5. The pronotal swellings have equivalents in the pupa of the Peruvian *S. lindenii* described by Onore (1994) but the transverse abdominal ridges of *S. munchowae* do not.

Life History of S. queenslandicus. With knowledge of the breeding behaviour of *S. munchowae*, the authors and Mr Jack Hasenpusch have searched intensively on several occasions at the Mt Lewis type locality of the North Queensland species for its immature stages, without success.

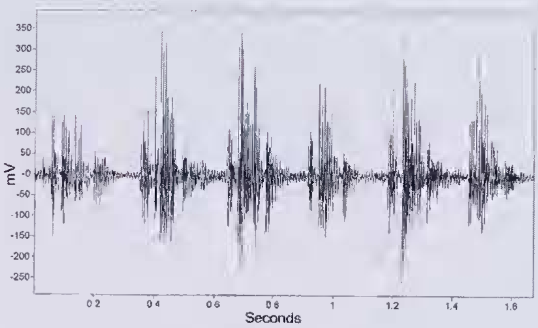

FIG. 6. *Sphaenognathus (Australognathus) munchowae* sp. nov., sonagram of stridulation of third instar larva (courtesy, Hannelore Hoch).

ACKNOWLEDGEMENTS

We are grateful to the following people. Geoff Thompson, created the fine textured illustrations in Figs 1-3. Elizabeth Munchow, as a schoolgirl on an outing to Blackdown 31 years ago, collected the first specimen of the new species, and Ernest Adams passed it to the ANIC. Hannelore Hoch and Manfred Asche, of the Humboldt Museum in Berlin, recorded larval stridulation during a visit to Brisbane. Queensland Parks and Wildlife Service issued permits to enable collection of the species in reserves and Craig Eddie, of that Service, collected stag beetles for the Queensland Museum during their vertebrate survey at Consuelo in 2001-02. Chris Burwell and Susan Wright helped with collecting at Consuelo in 1996. Ross Storey, Jack Hasenpusch and Tony Hiller all assisted in attempts to rear adults from the intractable larvae of the new species.

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